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P.A. Jumars, Arthur R.M. Nowell, J.W. Deming, Principal Investigators
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1. This confirms our conversations of 27 Feb 97 and 11 Jul 97. Enclosed are a number of technical reports which were returned to our agency for lack of clear distribution availability statement. This confirms that all reports are unclassified and are "APPROVED FOR PUBLIC RELEASE" with no restrictions.

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ROBERT J. SILVERMAN

Final Technical Report

Dynamics of Interactions among Particles, Fluids and Biota and Imposing of Multiple Constraints as a General Strategy for Interdisciplinary Problems

Grant N00014-90-J-1078

P. A. Jumars, Arthur R.M. Nowell and J.W. Deming, Principal Investigators

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This grant finished our focused, simultaneous efforts on the mechanics of particle coagulation in the water column, of suspension feeding in the water column and the benthos, and of particle deposition to the seabed. These efforts resulted, respectively, in three Ph.D. dissertations:

Hill, P.S. 1992. Reconciling aggregation theory with observed vertical fluxes following phytoplankton blooms. Ph.D. Dissertation, Univ. of Washington, Seattle. 103 pp.

Shimeta, J. 1993. Mechanisms and rates of particle encounter among suspension feeders. Ph.D. Dissertation, Univ. of Washington, Seattle. 210 pp.

Dade, W.B. 1992. Studies on boundary conditions for fine-sediment transport. Ph.D. Dissertation, Univ. of Washington, Seattle. 269 pp.

The grant was also credited with several publications:

Jumars, P.A., L.M. Mayer, J.W. Deming, J. A. Baross, and R.A. Wheatcroft. 1990. Deep-sea deposit-feeding strategies suggested by environmental and feeding constraints. *Phil. Trans. Roy. Soc. London A* **331:** 85-101.

Dade, W.B., A.R.M. Nowell and P.A. Jumars 1991. Mass arrival mechanisms and clay deposition at the seafloor. Pp. 161-165 in R. H. Bennett, W.R. Bryant and M.H. Hulbert, Eds. *Microstructure of Fine-Grained Sediments - — from mud to shale.* Springer-Verlag, NY.

Shimeta, J.S., and P.A. Jumars. 1991. Mechanisms of particle encounter by suspension feeders. *Oceanogr. Mar. Biol. Ann. Rev.* **29:** 191-257.

Dade, W.B., A.R.M. Nowell and P.A. Jumars. 1991. Predicting the erosion resistance of muds. *Mar. Geol.* **105:** 285-297.

Dade, W.B. 1992. Near-bed turbulence and hydrodynamic control of diffusional mass transfer at the seafloor. *Limnol. Oceanogr.* **37:** 52-69.

Hill, P.S. 1992. Reconciling aggregation theory with observed vertical fluxes following phytoplankton blooms. *J. Geophys. Res.* **97:** 2295-2308.

Hill, P.S., A.R.M. Nowell, and P.A. Jumars. 1992. Encounter rate by turbulent shear of particles similar in diameter to the Kolmogorov scale. *J. Mar. Res.* **50:** 643-668.

Jumars, P.A. 1993. Gourmands of mud: Diet selection in marine deposit feeders. pp. 124-156 in R.N. Hughes, Ed. *Mechanisms of Diet Choice,* Blackwell Scientific Publishers, Oxford.

Jumars, P.A. 1993. *Concepts in Biological Oceanography: An Interdisciplinary Primer.* Oxford Univ. Press, NY, 348 pp.

Jumars, P.A., J.W. Deming, P.S. Hill, L. Karp-Boss, P.L. Yager and W.B. Dade. 1993. Physical constraints on marine osmotrophy in an optimal foraging context. *Mar. Microbial Food Webs* **7:** 121-159.

Shimeta, J., P.A. Jumars and E.J. Lessard. 1995. Influences of turbulence on suspension feeding by planktonic protozoa; experiments in laminar shear fields. *Limnol. Oceanogr.* **40:** in press.

In finishing the efforts on particle mechanics, several important advances were made. In aggregation theory, we forced consistency upon the representation of coagulation kernels, incorporating a hydrodynamic retardation term in each. Doing so removed much of the apparent disparity in magnitude between shear coagulation and differential settling posited in the literature. Our laboratory results for coagulation, in turn, showed that the super-Kolmogorov and sub-Kolmogorov formulae did not match at the Kolmogorov scale, as they should if the derivations and

representations are correct. The super-Kolmogorov parameterization appears to extend below the nominal Kolmogorov scale, enhancing encounter rates above the levels predicted by sub-Kolmogorov theory. The experiments were the first to evaluate encounter independently of adhesion upon encounter.

In suspension feeding, we rederived consistent theory to predict rates of particle encounter by suspension feeders. Prior derivations were of "efficiencies," useful in evaluating technologies for scrubbing smokestacks, but less so in evaluating net gain to marine suspension feeders. We debunked the common notion that all suspension feeding occurs at low Reynolds numbers by simulating typical benthic flow velocities and evaluating encounter with simulated appendages, and we showed that viscous shears from dissipating turbulence are dramatically effective in increasing encounter rates of some kinds of planktonic protists with their bacterial foods.

In studies of fluxes at the seabed, we derived equations that carry both the turbulent and viscous terms for transport and thus are very useful in ubiquitous transitional flows. Biogenic roughness was shown to have a large effect on mass transfer over large areas of the seafloor.

Lastly, we began a new effort in optimal foraging theory for marine bacteria and phytoplankton. Among other successes, it predicted that cells should be larger at higher nutrient concentrations, replacing the idea that smaller is always better for osmotrophs.